SCIENCE

FRIDAY, JULY 1, 1921

MSS. intended for publication and books, etc., intended for review should be sent to The Editor of Science, Garrison-on-Hudson, N. Y.

THE SIGNIFICANCE OF RADIUM [1]

WE are met to-night to honor a discovery and the discoverer, and we are doing it in a way which I am sure delights her soul as much as it does mine. The custom of mankind, when it would do honor to one who has had the good fortune to be of service to his fellows, is to make a hundred thousand dollar parade, or to fire a hundred thousand dollar salute, or, in rarer instances of sounder judgment, to build a hundred thousand dollar monument. Compare that sort of an expenditure of the fruits of human toil with the glad donation which you are making to-night of a hundred thousand dollars, not merely for the alleviation of suffering and the arrest of disease—that is important—but for something which is vastly more important and more fundamental than that, namely, for the purpose of making it possible to peer farther into the secrets of matter, for upon that vision and the control of nature which that vision must precede depends the weal or woe of our children and our children's children for countless generations.

I wish to add a second element of uniqueness to this occasion. Knowing Madame Curie, as I have had the good fortune to do, I am sure that she would not wish me to speak a word of fulsome praise or to picture her as a superman; she is that because she is a woman, but not because she has had the capacity and the good fortune to make discoveries of the first importance. It is a common and a pathetic spectacle to see military, political, and social leaders who come conspicuously into the public gaze, lose their sense of perspective and begin to regard themselves as holding a commission from the Al-

[1] An address delivered at the National Museum, Washington, D. C., on the evening of May 25, in connection with the presentation of a gram of radium to Madame Curie.

mighty. I have never known a great scientist to make that blunder. And there ought never to be one who makes it because the business of science is to see things as they are. Madame Curie has always remained simple, modest and unaffected in the face of the world's applause. That is the highest compliment which a fellow scientist can pay her, and the surest sign that she is not an ordinary person. With that I have paid my tribute of respect and honor and admiration to the discoverer.

Now for the discovery. How did it come about? What is it? What is its significance immediate? What is its significance remote and far-reaching? In order to answer that series of questions I wish to begin by disabusing your minds of the idea, if they harbor it, that a discovery in science is an isolated event. A science grows in the main as does a planet by the process of infinitesimal accretion. Practically every experiment in physics is a modification of an experiment which has gone before. Almost every new theory is built like a great mediæval cathedral, through the addition by many builders of many different elements, one adding a little here and another a little there so that to the eye of a distant observer in the clouds the whole structure seems to move forward in a practically continuous way. Even when you get close up and begin to see the discontinuities, for they are there, each experiment in the development of a given field of science is found to have a pedigree just as truly as has a race horse. Man-o'-war did not develop his marvelous speed in one generation. A dozen sires and dams contributed to that result. In precisely the same way, when in 1896 Henri Becquerel, professor of physics in the University of Paris, discovered the new, extraordinary property which certain types of matter were found to possess and which was named radio-activity, that discovery was sired by one made a year before by Roentgen, and Roentgen's was sired by Leonard's, and Leonard's by that of Hertz in 1886, and Hertz's by the work of Maxwell, and Maxwell's by that of Faraday in 1831, and Faraday's by that of Oersted in 1819, and Oersted's by Volta's, and Volta's by Franklin's, and so on without limit. And the point to which I wish to call your attention now is that it is of incalculable importance that there should be people like those who have given this gramme of radium to Madame Curie who have a vision that extends, not to this generation only, but to the generations that are to come a hundred, two hundred years ahead, and who consciously set about starting such a train of scientific discovery and progress.

But for our present purpose I wish to break into this chain of scientific development at the discovery by Professor Becquerel of this extraordinary phenomenon of radio-activity made in the physical laboratory in which Madame Curie had been studying for some years. The discovery itself was really a simple thing, as are practically all great discoveries. The year before Roentgen had found his X-rays, as he called them, which had the peculiar property of making it possible for one to see his own skeleton. That attracted the world's attention and Professor Becquerel was endeavoring to see whether rays that would penetrate in that fashion could be produced from other sources. He naturally took uranium, because of its fluorescent property, to see whether it, under the action of light, might perhaps transmute the light waves into penetrating waves of the kind Roentgen had obtained. What did he find? He tried it in the light and he tried it in the dark, and he found that it was not necessary to have light at all, but that a bit of uranium put away in a black paper on top of a photograph plate, itself would blacken the plate. In other words, there was a property of self-activity in that uranium. It emitted rays of some kind which would affect a photographic plate and discharge an electroscope. The discharge of an electroscope, in popular language, is simply this: When you comb your hair on a cold winter day and it stands out in all directions, it is because it becomes electrically charged. If now a bit of radioactive substance is held above your head, your hair will fall down again, *i.e.*, your electroscope will be discharged. The laboratory electroscope is merely a gold-leaf which stands out like your hair when it

is charged and collapses when it is discharged. The electroscope then became the chief agent by which radio-activity could be tested, and Madame Curie with her husband—for she had been married the year before to Pierre Curie, professor of chemistry in the University of Paris—began the study of other substances than uranium to see how general this new property was, and they found that the two heaviest elements in nature, uranium and thorium alone of the then known elements, possessed it, but they also found that the natural ore of uranium, which we commonly call pitchblende, and which is more than fifty per cent. uranium oxide, although it contains many other minerals like barium and lead and bismuth—that this pitchblende discharged the electroscope approximately four times as fast as did pure uranium oxide. This meant, as the Curies at once interpreted it, that there must be some hidden elements in the pitchblende which had the same radio-active property as uranium but in larger degree. And so they began the search to see if they could not separate the element which was responsible for that activity, and after two or three years of arduous work Madame and Monsieur Curie were able to announce that, by using the ordinary methods of chemical analysis, by making precipitates and testing the activity both of the precipitate and filtrate to see with which the activity went and therefore what were the chemical properties of the substances that had it, they had been able definitely to discover the existence of these two new radio-active elements of which Dr. Walcott spoke. The first of these did not exist in sufficient amount so that it could be detected by any other properties than its activity. This was named polonium, in honor of the land in which Madame Curie was born, for her father was a professor in the Technische Hochschule at Warsaw. This polonium, by the way, has been one of our most useful agents in getting at the inner properties of the atom, because is has the power of emitting one type of ray alone and not a mixture of rays as does the other and more famous radio-active element which the Curies discovered. This other new element they named, appropriately, radium because it had a radio-activity a million times, weight for weight, that of the pitchblende, and three or four million times that of pure uranium.

This is the simple, unadorned tale of the discovery of radium, but I am sure you do not appreciate the kind of painstaking research and labor which that simple tale represents. You may perhaps get a little glimpse of what it means—of what a search for a needle in a haystack it was—when I say that the amount of radium in uranium is one part in 3,200,000; or that, in order to get the little gram of radium which is being presented to Madame Curie to-day it was necessary to take 500 tons of Colorado carnotite ore, which possesses two per cent. of uranium and to treat it with 500 tons of chemicals, apart from water and coal. So that, you see, the problem of bringing to a successful issue that search was one that places Madame Curie and her husband in the front rank of the world's scientific men and women.

The Nobel prize for 1903 was awarded jointly to Henri Becquerel and Monsieur and Madame Curie for their studies in radio-activity, and in 1911 the Nobel Prize was awarded to Madame Curie alone for isolating radium—getting it as a pure metal (in the early experiments it was a bromide or chloride), and for determining its atomic weight, which comes at 226.0. The heaviest element, uranium, has an atomic weight of 238, so that this is only twelve units lower than that.

So much for the way in which the discovery came about. But what is radio-activity? Perhaps I can tell you in as few words as possible by this simple statement. This gram of radium which you are giving to Madame Curie to-day, the volume of which is just that which I hold in my hand, and which you can see when the room is darkened—that gram of radium is continuously shooting off per second 145,000 billion particles which we call alpha particles, and with speeds which reach the stupendous value of twelve thousand miles per second. Now, when you recall that the super-guns which bombarded Paris could not

eject a projectile with a speed of more than about a mile per second, you see how feeble imitations of nature we have as yet been able to produce. No band of Mexican bandits running amuck on a Texas town can compare for a moment with a colony of radium atoms which perpetually bombard their neighbors with broadsides having muzzle velocities of 12,000 miles per second. Not only that; these atoms of radium have lighter ordnance also. They shoot off in addition each second 71,000 billion particles that are one eight-thousandth as heavy as these particles which I have called the alpha particles, and which are essentially helium atoms. If we call these alpha particles the 13-inch guns of the radium atoms, then we might say that they have also seventy-five millimeter guns which shoot off relatively light projectiles. These, however, have a speed which is more than ten times as great as that of the alpha particles. We call them beta rays. They are simply free negative electrons, endowed with a speed which is close to the speed of light, namely, close to 186,000 miles per second. But even that is not all. There is still one other type of rays that are being given off by this gram of radium. These other rays are the wireless waves of the denizens of the sub-microscopic world. They are ether waves just like light or just like wireless waves, except that the vibration frequency—the number of oscillations per second which the electronic inhabitants of the atom send off—amounts to thirty billion billions per second. These are the so-called gamma rays.

Now as to penetrating powers. The alpha rays or helium atoms, shoot right through the walls of a thin glass tube just as though there were no wall there at all, and that, in itself, has thrown new light on the structure of matter. It has shown us that the atom is itself an existence which is mostly empty space. It is like a miniature solar system through which it is entirely possible for a new satellite or planet to shoot without meeting anything. One of these alpha particles shoots on through hundreds of thousands of atoms before it is brought to rest. It goes through seven centimeters of air which is of the order of a third of a foot. That is as far as the heavy projectiles which are shot off from the radium atoms can go. The lighter ordnance shoots a hundred times as far and the gamma rays are a hundred times more penetrating still. I have thought you would be interested in actually seeing for yourselves the effects of these rays. I shall show first the effect of the gamma rays because, being those that are used in therapeutics, they are the ones you are most likely to be interested in. The gamma rays are simply ether radiations of very short wave-length, and whenever they pass through the atoms of matter they have the extraordinary power of ejecting with great speed from these atoms the electrons which are contained within them. And when these electrons pass in turn through other atoms they knock new electrons out of these atoms and thus put many of them into a condition in which they can make new combinations more readily than when they are not thus "*ionized.*" Now there can scarcely be any doubt that the therapeutic effects of radium are simply due to the fact that these ionized atoms have been put into a condition to make new chemical unions, *i.e.,* to produce new substances which are destructive of the normal tissues as well as of the cells of the disease which it is desired to destroy. But in some instances, at least, the disease is more susceptible than are the normal cells and consequently it becomes possible to arrest the growth of those disease cells. As a matter of fact, so far as the therapeutic effects of radium are concerned, the doctors who are in charge of the radium institutes will all tell you that you must not regard radio-active treatment as a cure for cancer. The only cure for cancer—the only certain cure—is surgical. Nevertheless, the effects of radium rays are to retard the growth of the malignant tumors and therefore to prolong life, so that, even in the case of cancers which are not capable of being operated upon—deep-seated concers—life can often be prolonged several years by radium treatment.

The medical specialists will also tell you that there are certain types of superficial tumors and skin diseases which can be perma-

nently and effectively cured, so that this kind of treatment has already been of sufficient use in therapy so that all who are familiar with it are at one in believing that it is highly desirable to introduce in all large centers of population these radium and X-ray hospitals of the kind which exist in Boston, New York, Chicago, Buffalo, Los Angeles, and several other cities, and which Paris is now to have because of the gift which you are making to Madame Curie.

The electroscope which by looking at the inverted image upon the screen you now see discharging rapidly under the influence of the gamma rays from the radium, is exposed only to the rays which have passed through more than a half inch of lead; for the radium is completely enclosed in lead walls of that thickness. This gives you some idea of the marvelous penetrating power of these gamma rays. I now wish to show you some of Dr. C. T. R. Wilson's photographs of the actual tracks of the alpha, beta and gamma rays through air. After seeing these straight line tracks of the alpha and beta rays you will not doubt that radium is actually shooting off big and little projectiles of the kind I told you about. The wiggly, snaky tracks due to the gamma and X-rays are perhaps even more interesting and enable you to visualize somewhat what goes on in your body when you are taking X-ray treatment. Can you now wonder that these rays tend to destroy the tissues and to produce burns?

Now a word as to the significance of this radio-active process. The therapeutic significance I have already referred to, but from my point of view the insight which radium gives into the nature of matter is of vastly more importance than any possible effects it has in the cure of disease or in the alleviation of pain. Twenty-five years ago if we had been told that any kind of matter possessed the property of throwing out projectiles with these enormous speeds we would have said "impossible." But not only in the enormity of the speeds of these projectiles is radium astonishing and revolutionary. There is something sublime about its ceaseless, unaltering and apparently unalterable activity, its complete indifference to intense heat or to extreme cold, to electrical or to chemical treatment of any kind. It is a property of the atom itself which we can not at present control in any way.

But the third effect of this discovery is more important still, for what does it show that matter is doing? These alpha particles which are being shot off are portions of the atom of uranium or of the atom of radium and the thing which is left after the ejection of the alpha particle from an atom of uranium is no longer uranium. Its chemical and physical properties have entirely changed. The uranium atom in shooting off one of these alpha particles is thereby transmuting itself into another element. When it has shot off three alpha particles it has transmuted itself into radium, and when it has shot off five more it has transmuted itself into lead. We have seen in the laboratory the growth of lead out of uranium, and have followed the whole chain of transmutation of elements through this radio-active process. This necessitates a conception of the nature of matter which was absolutely foreign to our thinking in the nineteenth century, and it is revolutionary in its significance. It means that these "eternal" elements—this radium and this uranium which we have here—are not eternal at all. The average life of the atoms of this radium is just 2,500 years, and after that time the average atom will have disappeared as radium, and if the world's supply of radium has not then mostly disappeared it will be because new radium is being produced all the time out of uranium. But uranium is the heaviest element we know of, and what is happening to it? It too is disappearing. But whence came it? It is true that the average life of the uranium atom is approximately eight billion years, so that when you go back so far as that, you may be inclined to say that it doesn't make much difference to this particular Republican administration where it did come from. Ah, but wait! In your thinking you have been forced to admit for the first time in history not only the possibility but the fact of the growth and decay of the elements

of matter. With radium and with uranium we do not see anything but the decay. And yet somewhere, somehow, it is almost certain that these elements must be continually forming. They are probably being put together now somewhere in the laboratories of the stars. That is still something of a guess, it is true, and yet the spectra of the nebulæ show that they contain only the lighter elements. Can we ever learn to control the process? Why not? Only research can tell. What is it worth to try it? A million dollars? A hundred million? A billion? It would be worth that much if it failed, for you could count on more than that amount in by-products. And if it succeeded—a new world for man! But what have we got already through the discovery of radio-activity? An immensely stimulating new conception of the universe and of the way matter is behaving.

Next the significance of radium with respect to the question of the availability of energy. The amount of heat given off from one gram of radium in disintegrating into lead is 300,000 times as much as the amount of heat given off in the burning of one gram of coal. There is, then, in the radium a supply of sub-atomic energy, and this raises the question as to whether such energy exists locked up in other atoms and as to whether there is any possible way we can get at it? Do not be too sanguine about it as far as radium is concerned, because if all the radium at present in the world were set to work, although it is 300,000 times as potent as coal per gram in giving off energy, it would not suffice to keep the corner popcorn man's outfit going. It does not exist in sufficient quantity.

But what has its discovery done then in the field of energy? It has opened our eyes to the fact that certain kinds of matter certainly possess these stores of energy and it is almost a foregone conclusion that similar stores are also possessed by the atoms which we have not yet found to be changing—which are not radio-active. The astronomer has for years been completely puzzled to account for enormous amounts of energy which the sun and stars emit. He has not been able to find its source. It is impossible that the sun is simply a hot body cooling off, because we have evidence that it has lived longer than it could have lived if that were the case. The astronomer has now, however, seized upon the facts of radio-activity and surmises that these sub-atomic energies may be the source of the sun's radiation. If so the supplies are not so limited as we thought.

Look now at another side of this same problem. I am thinking particularly of the work of Professor Joly and Lord Rayleigh, who have made measurements of the amount of radio-activity of the ordinary surface rocks. Professor Joly has computed that if there are two parts of radio-active material for every million million parts of other matter throughout the whole volume of the earth, and this is considerably less than he has found on the average in the earth's crust, then this earth, instead of cooling off, is actually now heating up; so that in a hundred million years the temperature of its core will have risen through 1,800 degrees centigrade. That is a temperature which will melt almost all of our ordinary substances. What does it mean? It means that the life history of our planet is perhaps not at all what we have heretofore thought that it was. It means that a planet that seems to be dead, as this our earth seems to be, may, a few eons hence, be a luminous body, and that it may go through periods of expansion when it radiates enormously, and then of contraction when it becomes like our present earth, a body which is a heat insulator and holds in its interior the energy given off by radio-active processes, until another period of luminosity ensues. What I am now pointing out is the growth in our conception of the world, the growth in the thoughts of men that has come out from these studies. Do not think that this is not of importance. When Galileo discovered the moons of Jupiter he was doing just about as useless a thing from the standpoint of its immediate applicability to human relations as he could have found to do. And yet what did he actually accomplish? He started off the train of

thought, the mode of attack upon physical problems which has made this industrial age what it is, and therein lies the tremendous significance of a discovery of the kind which we are honoring to-night.

We are so close to this age in which we live that we do not see what it means; we do not see it in its relation to other centuries. And therefore I should like to take you up in an Einstein airplane that violates all the relations of space and time so that you may see with me a few spots in geography and in time. Suppose we sail first, in the present, to the banks of the Tigris or Euphrates and see a picture which Professor Breasted drew to my attention when he came back from a recent mission to the near east. He pictured the inhabitants of that region tilling the ground with a crooked stick, bringing their hard-earned produce to the shores of the river, putting it on crude rafts which were made from the skins of goats and sheep, and paddling it laboriously across to the other side. Then he threw on the screen a photograph of an ancient Babylonian tablet which showed the inhabitants of that region four thousand years ago doing exactly the same thing in exactly the same way. Four thousand years without a bit of progress—each generation simply following the last in living a miserable existence, reproducing its kind and then passing on. Leave that! It is a discouraging picture.

Fly over into India and see this! I heard last winter Mr. Sam Higinbotham describe the conditions prevailing in that land now, where, as he said, millions of men go out into the fields in the morning with only a handful of grain—all they have to eat for the day; work a long day in perpetual hunger and feel that they would be perfectly happy if they could get all they wanted of such raw grain to eat. What wonder that Heaven for these men is Nirvana—the escape from existence!

Now fly over China. To do so, you have only to look at the sign in front of this museum: "Millions starving to death in China unless they can get help from this western world!" Discouraging pictures! What is wrong with the world? Fly back to this country and perhaps the following sights may suggest an answer. Circle above the Mississippi near New Orleans, and contrast what you see with the picture on the banks of the Tigris. See a train on the Southern Pacific Road bearing five hundred tons of produce from Texas, pulled upon a great ferry without even uncoupling the engine. See it in fifteen minutes on the other side ready to distribute its huge load of food stuffs raised with the aid of automatic planters, tractor-plows and steam threshers on the broad plains of the west, to the millions of inhabitants in the eastern half of our country. Or, again, fly over the biggest copper mine in the world which is near Salt Lake City and look at a mountain of two per cent. copper being shoveled away by great steam shovels with comparatively little human labor. See forty thousand tons a day of ore pulled in huge hundred-ton cars a few miles to the mill. Then see one of those huge cars elevated, wheels and all with no apparent human assistance, sixty feet high, turned slowly over and made to dump its load of ore into the mighty mill where a great, senseless, iron Cyclops grinds it into powder. Then watch the unseen natural forces of cohesion and adhesion in the flotation process pick out the ore from the gangue, without human aid, though controlled by human brains, and thus produce from sources altogether unusable fifteen years ago, the cheapest copper which the world has ever seen, the copper with which you are now harnessing new water power and building new electric railroads across the continent, with which famine is made an impossibility in any part of these United States.

Now, what is the most essential and most significant element of difference betweeen the two pictures which you have seen, the one here, the other half way around the earth? In this country, where the giant forces of nature have been set at work, the cheapest paid laborer on a building or in a steel plant, or on a farm, got before the war for eight or nine hours of labor, and he gets now, more than twenty times as much, not merely in money but in actual goods to be purchased with his

money, as does that man in India or in China. In other words, the common, unskilled laboring man in America has more than twenty slaves, but they are senseless, iron slaves, each of the same effectiveness as a common Indian laborer, who are doing his work for him. Why? Because Galileo and a few men like him a few hundred years ago got the idea that it was important to study out how nature worked. It is that study which has resulted in this modern scientific and industrial age. And it is only in the regions of the earth where that idea has got started, namely, in Western Europe and in this country, where the conditions under which the average man lives and works have been thus alleviated. Note that I say "have been" not "are to be." True, they may be immensely more improved than they are now. I can see little, immediate, practical needs as well as you. But let us not yet alight from our airplane. When you look at what *has already be done* by the advance of modern science—by getting an idea into a few men's minds—you begin to see that, after all, the important thing in this world is not the immediately practicable; the important thing is the growth of the human mind, the development of a few big ideas. Other things come from that, and therein lies the far-reaching significance of the experiments with radium; they have opened our eyes to new possibilities; they have given us a new conception of the growth and decay of the elements, and of the possibility of the human control of these processes; they have revealed the existence of new sources of energy which some time we may hope to be able to tap, and with the aid of which we may perhaps enrich human life in as yet undreamed of measure.

The first step is to see whether it is possible by any means at our control, to disintegrate atoms. And we have already found that we can do it, and radium has helped us to make that discovery. But we have only begun on this type of work. Its possibilities are untold.

From my point of view there are two things of immense importance in this world, two ideas or beliefs upon which, in the last analysis, the weal or woe of the race depends, and I am not going to say that belief in the possibilities of scientific progress is the most important. *The most important thing in the world is a belief in the reality of moral and spiritual values.* It was because we lost that belief that the world war came, and if we do not now find a way to regain and to strengthen that belief, then science is of no value. But, on the other hand, it is also true that even with that belief there is little hope of progress except through its twin sister, only second in importance, namely, belief in the spirit and the method of Galileo, of Newton, of Faraday, and of the other great builders of this modern scientific age—this age of the understanding and the control of nature, upon which let us hope we are just entering. For while a starving man may indeed be supremely happy, it is certain that he can not be happy very long. So long as man is a physical being, his spiritual and his physical well-being can not be disentangled. No efforts toward social readjustments or toward the redistribution of wealth have one thousandth as large a chance of contributing to human well-being as have the efforts of the physicist, the chemist, and the biologist toward the better understanding and the better control of nature.

Finally, the most significant thing about this evening is the way in which this contribution to further progress has been made: Not through a public grant—that is not the method through which the genius of Anglo-Saxon civilization has ever expressed itself, but rather through private initiative. A large group of public-spirited people have, of their own free will, decided that they wished to have a part in the development of a new chain of scientific discovery. It is that spirit and that method which has made America what it is, and it is in the spread of that sort of intelligence among one hundred million people that our future lies.

R. A. MILLIKAN

UNIVERSITY OF CHICAGO

LINCOLN WARE RIDDLE

THE following minute on the life and services of Professor Riddle was placed upon the records of the Faculty of Arts and Sciences of Harvard University at the meeting of June 7, 1921:

Lincoln Ware Riddle was born in Jamaica Plain, Mass., October 17, 1880. He graduated from Harvard in 1902, received the degree of A.M. in 1905, and of Ph.D. in 1906. In the same year he became instructor in botany at Wellesley College. He was appointed professor of botany there in 1917 and held this position for two years, when he came to Harvard as assistant professor of cryptogamic botany and associate curator of the cryptogamic herbarium. At the close of his first year of service upon our faculty he was attacked by the prolonged illness which terminated fatally on the 16th of last January.

The rare enthusiasm and singular devotion which he brought to his work were early made manifest. As a boy of twelve, at the Roxbury Latin School, he declared his purpose to devote his life to botany, and henceforth gave himself unreservedly to its pursuit.

At Wellesley he became deeply interested in lichens, and devoted himself more and more to the study of these plants. He made good use of the important lichen herbarium at Wellesley, and of the unique collection at Harvard, and in 1913, during a year's leave of absence in Europe, studied the collections in Upsala, Helsingfors, Geneva, London and Paris. His publications soon made him a leading authority on the subject.

He was constantly handicapped by a frail physique, but this did not prevent him from accomplishing important scientific work or from taking an active part in the affairs of the community. In his relations with his fellows he was the soul of honor and loyalty, with a personality that drew all men to him. In the class-room his sympathy and friendliness, as well as his clarity of style, made his teaching attractive. His devotion to his students was noteworthy and his influence great and lasting.

In the circle which mourns him his careful scholarship was widely esteemed by his professional associates; he was honored by all for his inspiring ideals, and, beyond the lot of most men, he was sincerely beloved.

WINTHROP J. V. OSTERHOUT,
ROLAND THAXTER,
MERRITT L. FERNALD,
Committee

SCIENTIFIC EVENTS

THE PRINTERS' STRIKE AND SCIENCE

IT is perhaps desirable to state that, owing to the strike of compositors for a forty-four hour week, the printers of SCIENCE continue to bring out the journal under serious difficulties. They have, for example, been unable to page the number of *The American Naturalist,* which should have appeared on May 1 and was in type at that time. Owing to the weekly publication of SCIENCE, it has been given precedence, the composition and make-up of the number having been largely done by the heads of departments. It has, however, been necessary to reduce the size of the numbers and to limit the amount of composition as closely as possible. Nearly all advertisers have cooperated with the publication department in using copy already in type and limiting as far as possible new composition. It may again be noted that the strike is nation-wide, affecting, in the east at least, the printing of most scientific journals.

GRANT FOR THE STUDY OF STELLAR PARALLAXES[1]

THE Advisory Council for Scientific and Industrial Research has quite recently granted an application made to it to assist in carrying out a piece of research work relating to the determination of the parallaxes of stars having a certain type of spectrum. The grant has been made to Mr. W. B. Rimmer, who up to the present has been employed in spectroscopic researches at the Imperial College of Science and Technology under the direction of Professor A. Fowler, but will now carry out this research at the Norman Lockyer Observatory at Salcombe Hill, Sidmouth. This observatory was founded by the late Sir Norman Lockyer in 1912, and the programme of work has been confined strictly to the photography of the spectra of stars and their subsequent classification according to his scheme of increasing and decreasing temperatures, which has been confirmed in its general features by the more recent work of Russell and Hertzsprung on giant and dwarf stars. The researches of Professor W. S. Adams have now

[1] From *Nature.*

rendered it possible to differentiate almost at a glance between a giant and a dwarf star. As a large amount of spectroscopic material was available at the Norman Lockyer Observatory for the application of Adams's method a trial research was begun. The method is based on a connection found by Adams to exist between the true brightness of a star and the intensity of certain lines in its spectrum. These line-intensities were determined by him by estimation, the plates being examined under a spectro-comparator. At the Norman Lockyer Observatory the method employed is to cover the lines gradually with a dark wedge, the position of which when a line is obliterated indicates the intensity of the line. The results of this trial research have proved very satisfactory, and were commented upon very favorably by Professor H. N. Russell on the occasion of a visit to the observatory. The above grant has been awarded to aid the extension of this research to all stars of suitable type down to declination —10° and of magnitude 6.5 and brighter. It is very opportune, for the staff of the observatory is small, and the work could not have been undertaken without such additional help.

HONORARY DEGREES CONFERRED BY YALE UNIVERSITY

At the commencement exercises on June 22 honorary degrees were conferred on several men of science. In presenting them Professor Phelps spoke as follows:

Master of Arts

Isaiah Bowman: formerly assistant professor of geography at Yale. Director of the American Geographical Society and editor of its *Bulletin*. He has led geological and geographical expeditions in South America. In 1917 he received the Gold Medal of the Geographical Society in Paris. He was the executive head of the house inquiry, being chosen for proved fitness. He did valuable work on boundaries for the Peace Commission in Paris. He is one more illustration of a college professor becoming so generally useful that the college is unable to keep him.

Doctors of Science

Hideyo Noguchi: distinguished Japanese scholar, M.D., Tokyo, 1897. He has made important discoveries in the treatment and prevention of smallpox and yellow fever. He is an honorary professor of three universities in South America; he has been given the Order of Merit by the Emperor of Japan. He is a striking fulfillment of the Scripture prophecy—"Seest thou a man diligent in business? He shall stand before kings." Dr. Noguchi has received the order of knighthood from three Kings—the Kings of Spain, Denmark and Sweden. Perhaps he appreciates even more than royal honcrs the admiration and gratitude of the people.

Madame Marie Curie: Marie Sklodowska was born in Warsaw and has always been a scientist; her father was a distinguished professor and her husband, Pierre Curie, will never be forgotten. She was educated at Warsaw and at Paris, and has been professor of radiology at Paris. It is superfluous to mention her discoveries in science, and now she has discovered America. She has often encountered dangers in scientific experiments, but nothing so dangerous as American hospitality; it is to be hoped she will not be a woman killed with kindness. She is unique. There is only one thing rarer than genius, and that is radium. She illustrates the combination of both.

Doctor of Laws

Sir Robert Jones: the leading British orthopædist. One of the many distinguished men contributed to the world by Wales. Lecturer on orthopædic surgery at the University of Liverpool; member of many learned societies, author of many books, recipient of many degrees to which number Yale is proud to add one more. Enormously useful during the war. He had charge of the orthopædic work of the British government 1914–1918. It is largely owing to him that England maintained during the war a position so characteristically upright.

James Rowland Angell: president-elect of Yale. Born in Vermont, a graduate of the University of Michigan. Professor and acting president of the University of Chicago. Exchange professor at the Sorbonne. At home anywhere and everywhere. Son of a great college president and ideally prepared to be one himself. Trained in scholarly research and in executive duties. A teacher of exceptional power. He has a thorough understanding of America's needs in higher edu-

cation and profound sympathy with Yale sentiment. A believer in physical and mental development; a scholar and a man. In choosing Dr. Angell as president, Yale has gone back to her earliest traditions, and, as was the case with her first five presidents, has taken a graduate of another institution. It was not until 1766 that a Yale graduate became president. Instead of having been a Yale man, he has spent his life preparing to be one.

HONORARY DEGREES AT HARVARD UNIVERSITY

HONORARY degrees were conferred at the commencement of Harvard University on June 23 on the men of science given below. In conferring these degrees President Lowell spoke as follows:

Master of Science

CARLOS CHAGAS, of Rio de Janeiro, Brazil. "Director of the Instituto Oswaldo Cruz, preeminent in the knowledge of tropical medicine in Brazil, discoverer of the nature and cause of the disease that bears his name."

Doctor of Science

SIR ROBERT JONES, of London, England. "The orthopædic surgeon who patiently and silently showed the way to restore to usefulness and comfort the cripples of the war."

GEORGE ELLERY HALE, director of Mt. Wilson Observatory at Pasadena, California. "Astronomer famous in two worlds, whose spectroheliograph has recorded light of the sun too strong and of the stars too faint for human sight."

HERBERT CHARLES MOFFITT, professor of medicine at the University of California. "The physician who built up for the University of California the great medical school of the Pacific Coast."

Doctor of Laws

JAMES ROWLAND ANGELL, new president of Yale University, Harvard A.M., '92. "A man tried in many posts, whose reputation has grown with every trial; worthy head of a university national in its scope, great in its history, great in its services to the nation, and greater still in its destiny."

SCIENTIFIC NOTES AND NEWS

PRINCETON UNIVERSITY, as well as Yale, Harvard and Columbia, has conferred the doctorate of laws on Dr. James Rowland Angell, president of Yale University.

THE degree of doctor of science has been conferred by Williams College on Dr. Henry Baldwin Ward, head of the department of zoology in the University of Illinois.

DARTMOUTH COLLEGE conferred at its recent commencement its doctorate of science on Dr. H. P. Talbot, professor of analytical chemistry at the Massachusetts Institute of Technology.

AT the commencement exercises of the New York State College for Teachers, Albany, on June 20, the honorary degree of doctor of pedagogy was conferred on Dr. C. Stuart Gager, director of the Brooklyn Botanic Garden. Dr. Gager delivered the address on June 18 at the unveiling of the bronze tablet in memory of students of the State College who lost their lives in the war.

THE degree of doctor of laws was conferred upon Dr. C. H. Mayo at the commencement exercises of Northwestern University on June 15.

DR. W. J. MAYO delivered the Henry Jacob Bigelow Medalist Address before the Boston Surgical Society on June 6, at which time he was awarded the Bigelow Gold Medal. The Henry Jacob Bigelow trust fund was established in 1916 by Dr. William Sturgis Bigelow, of Boston, in memory of his father, the income to be used by the Boston Surgical Society to award medals for valuable contributions to the advancement of surgery in this country or in other countries. Dr. Mayo is the first recipient of the medal.

DEAN THOMAS F. HOLGATE, of Northwestern University, has been invited by the University of Nanking, China, to spend his sabbatical year at that institution, lecturing on mathematical subjects and assisting in the general organization of the university. He sails for China on August 18 on the Empress of Asia.

DR. MARK F. BOYD, professor of bacteriology and preventive medicine in the Medical Department of the University of Texas since 1917, has resigned to enter the service of the International Health Board of the Rockefeller Foundation.

Dr. Juan Guiteras, formerly director of public health of Cuba, has been appointed secretary of public health and charities.

Dr. Edward B. Krumbhaar, assistant professor of research medicine in the University of Pennsylvania, has resigned to become director of the pathological laboratory of the Philadelphia Hospital.

Dr. J. F. Dillingworth, who, for the past four years, has been under engagement with the Queensland government, investigating pests of sugar cane, is returning with his family to their home in Hawaii. For the present his address will be University of Hawaii, Honolulu, T. H.

The commencement address at Clark University was given on June 13 by Dr. John M. Clarke. The occasion was the first commencement under the presidency of Dr. Wallace W. Atwood.

At a public meeting of the British National Union of Scientific Workers on May 25, Professor L. Bairstow gave an address on "The administration of scientific work."

At the meeting of the Physical Society of London on June 10, Sir Ernest Rutherford delivered a lecture entitled "The stability of atoms."

Sir Napier Shaw gave the Rede lecture of the University of Cambridge on June 9 on the subject of "The air and its ways."

Colonel John Herschel, F.R.S., formerly of the Indian Trigonometrical Survey, died on May 31 at the age of eighty-three years.

The death is recorded in *Nature* of Miss Czaplicka, who went from Poland to Oxford in 1910 with a scholarship in Summerville College. She has since conducted explorations in Siberia and has been lecturer on ethnology at Oxford and Bristol.

UNIVERSITY AND EDUCATIONAL NEWS

Gifts and bequests to Yale University in the past year aggregating $1,859,154 were announced at the alumni luncheon by President Hadley. Of this amount, $545,729 was from the alumni fund, the report of which showed more than eight thousand contributors during the year.

The California Legislature has appropriated $500,000 for building and equipping a new physics building for the University of California. Work has begun on the plans, and it is hoped that the building will be ready for occupancy by December, 1922. Liberal provision will be made for research, both in space and equipment, and ample laboratory accommodations will be provided for the undergraduate students, who have more than doubled in number during the past two years.

Mr. Samuel Mather has given to Western Reserve University $500,000 to be used in the construction of a building for the medical college.

Mrs. Ransohoff, widow of Dr. Joseph Ransohoff, former professor of surgery at the Medical College of the University of Cincinnati, has given $25,000 to this institution (*not* Cornell) toward the endowment fund for the establishment of "The Joseph Ransohoff Professorship of Surgical Anatomy," or if such is not feasible "to endow the Joseph Ransohoff Fellowship of Surgery." Effort is under way at the present time to secure the added $125,000 for the total endowment above mentioned.

The resignation of Dr. Russell H. Chittenden, director of the Sheffield Scientific School of Yale University, to take effect at the end of the college year has not been accepted by the trustees, and has been postponed to July, 1922.

Professor Dan T. Gray, of the North Carolina Experiment Station and Extension Service, has been elected dean of the Agricultural College and director of the Experiment Station of the Alabama Polytechnic Institute.

Recent appointments in Colorado College include A. W. Bray, as assistant professor of biology, and James H. C. Smith, as assistant professor of chemistry.

DISCUSSION AND CORRESPONDENCE

USE OF THE TERMS "EROSION," "DENUDATION," "CORRASION" AND "CORROSION"

I AM interested in Mr. Bissell's plea for a more precise term, in geological literature, of the terms, "erosion," "denudation," "corrosion" and "corrasion." Without entering into a discussion of the merits of various past definitions of these words, may I presume to express my own views on this subject?

"Erosion" means "gnawing away," and is properly used to include all natural processes which have their origin at the earth's surface and which involve the destruction of rocks at or near the earth's surface. This is the broadest term referring to surficial rock destruction. It embraces work performed by passive or motionless agents (weathering) and work performed by moving agents, such as running water, glacial ice, waves, and wind. It may be used correctly for rock destruction on the land or on the sea floor. Thus, we may speak of erosion of the sea floor by waves or by submarine currents, and of the erosion of rocks, exposed on land, by moving ice or by alternate contraction and expansion due to heating and cooling, etc., etc. While it must connote transportation and may connote deposition, it should not be used to include these dependent processes.

"Denudation," by derivation, refers specifically to *stripping* or *laying bare*. It is often used in the sense of natural removal of soil or mantle rock from underlying solid rock, or removal of one rock formation from one lying below. It refers to erosional processes which are destructional, and like erosion should not be used to denote transportation or deposition. Almost, if not quite, without exception, "denudation" refers to stripping (erosion) only on land, whether it is on a small scale or on a large scale.

"Corrasion" is mechanical erosion performed by moving agents such as wear by glacial ice, by wind, by running water, etc.

"Corrosion" is most commonly used for chemical erosion, whether accomplished by motionless or moving agents.

I have suggested the foregoing definitions always having in mind that the "rock" eroded may be consolidated or unconsolidated and that corrasion is accomplished largely by virtue of sand, silt, or other rock debris carried by the moving agent of erosion.

FREDERIC H. LAHEE

DALLAS, TEXAS,
May 11, 1921

THE BREEDING HABITS OF AMBYSTOMA TIGRINUM

THE eggs of *Ambystoma tigrinum* are usually described as occurring in small clumps. This is typical of the species in the eastern part of its range. While collecting in Colorado at an altitude between 6,000 and 7,000 feet, I found eggs of *tigrinum* laid singly. When first laid the egg resembles that of *Diemictylus*. As development continues the outer envelope becomes swollen until at the time of hatching its diameter is one half to three quarters of an inch. The eggs are attached to vegetation or debris. The depth varies from a few inches to two feet. On one occasion adults brought into the laboratory laid freely.

RALPH J. GILMORE

COLORADO COLLEGE,
COLORADO SPRINGS, COLO.

A PHENOMENAL SHOOT

AN extraordinary water-shoot, discovered by Mrs. B. W. Wells, near the city of Raleigh, N. C., on March 21, 1920, is of such unusual size as to deserve recording. The shoot sprang from the side of the trunk of a beheaded tree of *Paulawnia tomentosa* (Thunb.) Steud. and grew in one season (1919) to the length of 19 feet, 5 inches. Twenty internodes were formed, the longest of which, located a little below the middle of the shoot, measures 19 inches in length. The base of the shoot is 7.75 inches in circumference and 2.5 inches in diameter. Braunton in Bailey's Encyclopedia of Horticulture gives 14 feet as a maximum length of *Paulownia* shoots growing from the root after winter killing. The shoot recently discovered, exceeding this by 5 feet, 5 inches, is believed to be a record for

the tree type of woody plant in the temperate zone.

B. W. Wells

North Carolina State College

THE AURORA OF MAY 14, 1921

To the Editor of Science: A very fine display of northern lights was observed here on Saturday night May 14th to daylight Sunday morning. It was first observed at 8:30 P.M. and was most conspicuous in extremely bright patches here and there in the sky, lasting usually not over a minute, with long arcs crossing the northern horizon. It was slightly cloudy, especially overhead and toward the northeast, but bright patches of aurora could be seen through the clouds. The sky was clear in the west and here and there groups of fine lines were visible, having always a slant of 60 degrees from the horizontal, corresponding to the dip of the compass at Tucson.

The colors were a dull white changing to a greenish tint in the northerly glows, a brilliant pearly luster in the patches and an occasional strong red color over large indefinite areas.

The display appeared to become somewhat less intense at 10:30 but shortly afterward showed renewed activity especially in long lines extending over large parts of the sky, which was now nearly clear, and all pointing toward a vanishing point of perspective situated about 30 degrees south of the zenith and a little to the west of the meridian, which is the direction of our lines of magnetic force extending toward the south pole. This vanishing point was very beautiful and was observed by many people. By one o'clock the display had somewhat diminished, but a later view at 3:30 showed a perfectly clear sky and the ordinary arcs crossing the northerly horizon with occasional nearly vertical streamers extending upward.

This was observed in many other parts of Arizona and far exceeds the recollection of anything of the sort seen here in forty years. I have notes upon four previous occurrences. One was seen from Flagstaff, Arizona, in the winter of 1894 and 1895. One was reported to me on November 5, 1916, and faint displays were seen here on October 9 and December 13, 1920. This was the first display of northern lights for most of the people of this part of the country.

A. E. Douglass

Steward Observatory,
The University of Arizona

THE AURORA SEEN FROM SINALOA, MEXICO IN LATITUDE 27° N.

The Northern Light display of May 14 was very plainly visible from the mesa here—only a few miles from the tropics. The Indians have been firing the forests to hasten the advent of the summer rains, and, when I first observed the glow along the sky-line formed by the Sierra Madre I thought they were indulging in their propitiation of the gods on a rather larger scale than usual. The glow began about eight o'clock and the rays were first visible about fifteen minutes later. They were white to pale yellow in color, ever changing in form, location, and brightness. Many of them appeared to reach an east-and-west great circle through the zenith, those low down in the eastern sky appearing longer. The apparent focus was several degrees east of north.

I had never before witnessed such a display and never expected that my first observation of the aurora would be from the semi-tropics.

J. Gary Lindley

QUOTATIONS

THE MOUNT EVEREST EXPEDITION

The organization of the expedition is now complete, and all the members proceeding from England have left for India. The leader of the mountain party, Mr. Harold Raeburn, sailed from Birkenhead direct for Calcutta on March 18. Colonel Howard Bury, chief of the expedition, left Marseilles for Bombay on April 9, and Mr. G. H. Leigh Mallory, one of the young climbers, sailed from London direct for Calcutta on the preceding day. Mr. A. F. R. Wollaston, surgeon and naturalist, left Marseilles for Bombay on April 16, and by the same boat Mr. G. H. Bullock, who had been selected at the last moment to replace Mr. George Finch, who was unfortunately, owing to ill-health, unable to take part in the ex-

pedition this year. These gentlemen, with Dr. Kellas, who is already in India, complete the party of six from this country who will make the reconnaissance, and will, if conditions are favorable and the reconnaissance has clearly revealed the best route, make an attempt this year to reach a considerable height on the mountain. The survey operations will be entirely in the hands of the Survey of India, and we learn from the surveyor-general that Major Morshead and Captain Wheeler were under orders to leave Darjeeling about April 1 to carry forward a good triangulation on to the plateau of Tibet with a view to the ultimate determination of the deviations of gravity north of the Himalaya, the question of the first importance to Indian geodesy. At the request of the government of India an officer of the Indian Geological Survey will also accompany the expedition. The commander-in-chief in India, Lord Rawlinson, has responded very kindly to the request that he should assist the expedition by the loan of transport, and a letter has been received recently from the quartermaster-general detailing orders which have been issued for the selection of trained mules and their accompanying personnel. The transport train was to have assembled at Darjeeling on May 12, and the value of this assistance can hardly be overestimated.

At a recent party at Buckingham Palace the president was summoned both by the King and Queen to give them the latest news of the organization and plans of the expedition, and His Majesty has graciously shown his kind interest in the project by contributing the sum of £100 from the Privy Purse to the expedition's funds. The chief of the expedition, Colonel Howard Bury, was received before his departure by H.R.H. the Prince of Wales, Vice-Patron of the society, who, with the Duke of York, spent an hour examining the plans of the expedition, and expressed his keen interest and good wishes for its success; an expression that was followed almost immediately by a generous contribution of £50 to the funds of the expedition.

As a result of the appeals made by the president of this society and the Alpine Club a sum has been collected which is approximately sufficient for the work of the first season, but leaves little reserve. It is, therefore, greatly to be desired that all fellows of the society who are jealous for the success of the first important enterprise undertaken since the war, should, if they have not already done so, send subscriptions according to their means to the funds of the expedition.—*The Geographical Journal.*

SPECIAL ARTICLES

AN OUTLINE FOR VASCULAR PLANTS[1]

IF an attempt is made to prepare a numbered list of the orders and families of flowering plants, there should first be some agreement on the sequence of the major groups. For example, should the monocots precede or follow the dicots? Should gymnosperms and ferns be included in the enumeration, as they are included in our manuals? Unless these points are agreed upon, the enumeration will be premature.

It will first be necessary to bring together the work of anatomists, morphologists and systematists. A list prepared in this way should command the respect of all botanical workers, and all might be expected to follow the list. If this synthetic view is taken, we find the ferns, gymnosperms and angiosperms forming coordinate groups. And this series stands in coordinate relation with the lycopods and horse-tails taken together. It remains for some authority on taxonomy to embody these conclusions in the system. With a view to bringing such a system under criticism, we offer below a tentative arrangement of the larger groups of plants. If some such system is adopted—as must ultimately be—we could best number the orders and families of each class separately. Thus ferns and gymnosperms would have separate numerals from those allotted to angiosperms. It is to be hoped also that the dicots will be given a permanent place at the beginning of the angiospermic series. The entire series of vascular plants would appear thus:

[1] *Cf. Plant World,* 22: 59–70. March, 1919.

Lycopsida
Order 1. Lycopodiales
2. Equisetales
Pteropsida
Class 1. Aspermæ (Ferns)
2. Gymnospermæ
3. Angiospermæ
Subclass 1. Dicotyledoneæ
Division 1. Archichlamydeæ
Order 1. Casuarinales
Family 1. Casuarinaceæ
. . . .
Division 2. Metachlamydeæ
Subclass 2. Monocotyledoneæ
Order 41. Pandanales
. . . .
51. Orchidales
Family 284. Orchidaceæ

HENRY S. CONARD

GRINNELL, IOWA,
May 16, 1919

THE AMERICAN CHEMICAL SOCIETY

(*Continued*)

Studies in fluoride equilibria: I. Calcium borofluoride: A. F. O. GERMANN and GILBERTA TORREY. Moissan, in his work with boron trifluoride, passed the gas through a tube containing heated calcium fluoride, presumably to free the gas from any hydrogen fluoride that might contaminate it. Calcium borofluoride, $Ca(BF_4)_2$ is described in the literature, and it seemed reasonable to expect the formation of a similar compound under the conditions of Moissan's work. To determine this, weighed samples of calcium fluoride were heated for several days at a temperature of 200° C. in an atmosphere of pure boron trifluoride under a pressure of 430 mm. Absorption took place slowly, and until one half molecule of the gas was absorbed. Blanks were run to determine the amount of absorption by the glass, etc., of the reaction tube; this absorption was found to be slight. The compound, $2CaF_2.BF_3$, forms by direct union of the constituent molecules under the conditions outlined.

Chromatic emulsions: HARRY N. HOLMES and DONALD H. CAMERON. A "solution" of ordinary cellulose nitrate (11 per cent. nitrogen) may be somewhat diluted with benzene and then emulsified with glycerol. A creamy white emulsion of drops of glycerol in the other liquid results. With addition of enough benzene the indices of refraction of the two liquids may be made equal, thus securing a transparent emulsion. With the right amount of benzene a very beautiful yellow emulsion which is a soft blue by transmitted light is produced. The next step up in the "color chromatic scale" is a pink emulsion which transmits green light. Next a lavendar emulsion is made transmitting yellow light. With still more benzene a blue-green emulsion is secured with a sunset red glow by transmitted light. The colors are explained by the great difference in dispersive power of the two liquid phases, transparency being fundamentally necessary to let the light through.

Cellulose nitrate as an emulsifying agent: HARRY N. HOLMES and DON H. CAMERON. By the use of cellulose nitrate as an emulsifying agent emulsions of the "water-in-oil" type may be prepared. Cellulose esters containing about 11 per cent. nitrogen are most suitable. "Water-in-oil" emulsions are far less stable than the more usual "oil-in-water" type. To prepare the former such emulsifying agents as calcium and magnesium soaps, lanolin, carbon and rosin have been used. However, cellulose nitrate is far superior to these agents in the stability of the emulsions produced by its aid. For example, if water be shaken with a suspension of cellulose nitrate in amyl acetate (2 per cent. is suitable) a good white emulsion of drops of water dispersed in amyl acetate is obtained. Instead of amyl acetate any liquid that peptizes ("dissolves") the cellulose ester may be used provided also the two liquids are immiscible. One of the important factors in the formation of this emulsion is the formation of a tangible film around each drop. With a very large drop the film may be observed under suitable conditions. It is probably formed by great adsorption, to the point of coagulation of the cellulose nitrate at the liquid interface.

A theory of the photographic latent image: HARRIS D. HINELINE. The suggested theory concerns itself with the latent image as distinct from the photo-electric effect on the silver halide, and as distinct from the print out image. A reaction between the dissociation products of the silver halide and gelatine which will yield energy enough to account for the energy discrepancy pointed out by other workers, is suggested. In terms of this theory the latent image then consists of a combination between the bromine and substituted ammonia of the gelatine and the silver and amido acid, the amido acid compound being much more easily reducible than the bromine compound of

silver. This theory can account for the failure of the reciprocity law, for the shape of the H and D curve, for the phenomenon of reversal, and states the distinction between the latent image and the print-out image. The energy relationships are such as to indicate the formation of a considerable proportion of silver amido acid compound, which then becomes the material affected by the developer.

The interaction of platinum hydrogen acid and hydrogen peroxide: S. A. BRALEY and O. V. SHAFFER. Following the work of Rudnick in 1917 a study of the preparation of H_2PtCl_6 was made. It was found that commercial 3 per cent. H_2O_2 acted only very slowly on ignited platinum black, and on platinum sponge did not give H_2PtCl_6 suitable for accurate analytical work. By concentrating to about 30 per cent. and redistilling from quartz to quartz H_2O_2 was prepared which would give acid with a KCl factor of .3045 and suitable for accurate KCl determinations.

Is there a sharp transition point between the gel and sol? EUGENE C. BINGHAM. The viscometer gives a satisfactory method for distinguishing sharply between a liquid and a solid. Under the influence of a small shearing stress a liquid is continuously deformed, whereas a solid is not. The fluidities of a 10 per cent. gelatine sol in glycerol-water mixture of 1.175 sp. gr. calculated from the data of Arisz follow the equation

$$\phi = 0.000227 \ (t - 45.2)$$

very closely. This indicates that the fluidity would reach the zero value when the temperature becomes 45.2° C. At this point the substance would become a solid and there would appear to be a sharp transition point between the two states.

The validity of the additive fluidity formula: EUGENE C. BINGHAM and DELBERT F. BROWN. It is shown that in many mixtures of inert liquids there is a contraction of liquid in mixing. If this contraction is multiplied by a constant, which is usually about 2,000, one obtains the amount by which the observed fluidity differs from the value calculated on the additive formula. It is evident from the above that even in the case of so-called inert liquids there is an adjustment of the free volume, for which several equations have been proposed. These give as good agreement as can be expected with the data available.

The emulsion colloids as plastic substances: EUGENE C. BINGHAM and WILLIAM L. HYDEN. The fluidity-volume concentration curves of suspension colloids were found to be linear by Bingham and Durham, and the zero of fluidity served to demarcate between the viscous liquid and plastic solid. Nitrocellulose solutions in acetone present a new case, differing from all others studied up to the present. The fluidity of even very dilute solutions is not a constant but a function of the pressure. The solutions, therefore, act as plastic solids even in very dilute solutions. It is found to be convenient to measure the plasticity of such solutions in the viscometer. This has heretofore always been done on the plastometer.

The properties of cutting fluids: EUGENE C. BINGHAM. In cutting metals, fluids are often used, sometimes to lower the temperature, often to lubricate the surfaces between the tool and the chip. But whereas lubrication under the best conditions is merely a matter of viscosity, two oils of the same viscosity may have the most extraordinary difference in efficiency. The cutting oil *par excellence* is lard oil and it derives its superiority from its high *adhesion*. Mineral oils may have their lubricating efficiency raised by the addition of substances having high adhesion.

The diffusion of hydrogen through silica glass: JOHN B. FERGUSON and G. A. WILLIAMS. The results of a redetermination of the rates at which hydrogen will pass through silica glass at temperatures between 440° and 727° C., and at pressures between 0.5 and 1 atmosphere are herein presented. The fact that helium will pass through silica glass at a much faster rate than does hydrogen has been confirmed.

The atomic weight of nitrogen by the thermal decomposition of silver trinitride: HAROLD S. BOOTH. In this determination silver trinitride was slowly decomposed by heat in a suitable all-glass apparatus into silver and nitrogen, the evolved nitrogen passed through phosphorus pentoxide to absorb the traces of moisture retained in the interstices of the silver trinitride, and the nitrogen adsorbed in a charcoal tube immersed in liquid air. The method as planned involved no corrections except for errors in the weights. Every precaution was taken to insure the purity of the materials and the accuracy of the method. The average of fourteen determinations of the ratio 3N : Ag gave 14.007 for the atomic weight of nitrogen.

Studies in adsorption from solution: W. A. PATRICK and D. C. JONES. A study of adsorption in the capillaries of silica gelatine of a large number of two component systems has been partially

completed. A range of liquids from water up to the high petroleums has been investigated. The results have been examined in the light of existing theories. Qualitatively they appear in agreement with the Gibbs relation, those substances being adsorbed that lower the interfacial tension. Qualitatively they can not be represented at all by the Freundlich equation. A theory is advanced that solubility and the effects of the enormous curved surfaces present in the capillary pores are the determining factor.

Summary of study of system ammonia-water: W. A. Patrick and B. S. Neuhausen. (1) A static method has been developed for measuring the partial pressure of a component which is relatively very small compared to the partial pressure of the second component. (2) This method has been used to determine the partial pressures of water and ammonia of concentrated ammonia solutions at 0° C., 20° C., and 40° C., at partial pressures of ammonia varying from 1,000 to 4,000 mm. The partial pressures of the ammonia were measured to within 4 to 2 millimeters; and those of the water to 0.08 millimeter. (3) The solubility of ammonia in water was determined at 0° C., 20° C., and 40° C., at pressures from 750 to 3,600 mm. The densities of these solutions were also determined. (4) A theory of the nature of solution of gases in liquids first advanced by Graham has been amplified, and solutions of various gases in liquids classified on the basis of some of the physical and chemical properties of the gas. (5) The formula

$$V = K\left(\frac{P6}{Po}\right)\frac{1}{n}$$

has been found to represent well the solubility of ammonia in water at varied temperatures and pressures. In this formula V is the volume occupied by the liquefied gas dissolved per gram of water; p is the vapor tension and 6 the surface tension of the liquefied gas at the temperature while p is the equilibrium gas pressure. The constant k for ammonia has the value 0.49 and $1/n$ has the value 0.69.

Heat of wetting of silica gelatine: W. A. Patrick and R. C. Grimm. The amount of heat liberated when silica gelatine is wetted by a number of liquids has been accurately measured in an adiabatic calorimeter. The results have been examined from the standpoint of the surface energies involved. On the assumption that silica gelatine presents a surface that is essentially water, all of the experimental results were capable of being brought into agreement with the idea that the heat of wetting is essentially a manifestation of changes of surface energy. The heat of wetting of water between 0° and 4° was found to be positive and greater than that at 20°.

Adsorption by precipitates. IV. Acclimatization: Harry B. Weiser. The amount of electrolyte required to coagulate a colloid is influenced by the rate of addition. Since the quantity of electrolyte that will cause complete coagulation when the addition is rapid will not cause complete coagulation when the addition is slow, the colloid is said to become acclimatized and the phenomenon is called "acclimatization." This term is a misnomer. The dropwise addition of an electrolyte throughout a prolonged period is accompanied by fractional precipitation of the colloid. The excess electrolyte required to precipitate a colloid by the slow process is due to removal of precipitating ions by adsorption of the neutral particles during fractional precipitation. The factors which determine the excess electrolyte required for a given slow rate of addition are: (1) the extent to which the colloid undergoes fractional precipitation; (2) the adsorbing power of the precipitated colloid; and (3) the adsorbability of the precipitating ion.

The oxidation and luminescence of phosphorus. III. The catalytic action of vapors: Harry B. Weiser and Allen Garrison. Phosphorus trioxide is an intermediate product in the complete oxidation of phosphorus. The luminescence of phosphorus is due to the oxidation of this lower oxide. Certain vapors inhibit the oxidation of phosphorus and others accelerate the oxidation. Such substances are designated as catalysts, but they are not catalysts in the ordinary sense in which this term is used. The vapors are condensed or adsorbed on the charged or uncharged oxidation products of phosphorus (P_4O_6 and P_2O_5). If the vapors react with phosphorus trioxide they increase the rate of oxidation. If they are inert, they prevent further oxidation of phosphorus trioxide and also form a cloud near the surface of the phosphorus. This cloud approaches nearer and nearer the surface as the oxidation becomes less energetic and in certain cases may form a protecting film that stops the oxidation entirely.

Critical solution temperatures as criteria of liquid purity: D. C. Jones. (By title.)

Charles L. Parsons,
Secretary